The Study of Soil and Sediment Quality Indicators in Different Land Uses of North Karun Watershed (Cheshmeh Ali)

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1. Abstract

Improper uses of natural resources including soil and vegetation resources results in sever soil erosion and land degradation. In order to control soil degradation and erosion the contributed factors in soil degradation should be identified. Soil quality assessment is necessary for identifying the effects of different management systems on agricultural and natural resources including rangeland and forest. Appropriates indices would reflect the effects of management on soil quality in short time, should be identified. The objectives of this study were to compare selected soil quality indicators and to estimate the amount of sediment, runoff and nutrient loss in four different land uses including, a pasture with good vegetation cover (> 20%), pasture with poor vegetation cover (< 10%), currently being used dry land farm and degraded dry land farm which is not used. Soil samples were taken from the depth of 0–10 cm in a completely randomized design with four replications. Soil quality indicators including organic matter, total N, available P, cation exchange capacity (CEC), microbial respiration, mean weight diameter (MWD), bulk density and soil porosity were measured. A rainfall simulator was run for 2 hours to estimate the amount of sediment, runoff and nutrient loss. The results showed that a very high degradation has occurred in the area mostly due to water erosion created as a result of overgrazing in pasture, susceptibility of geological formations and more importantly, the change of land use pasture to inefficient dry land farming. According to land use change, organic matter decreased mostly 68.6% in dry land farm. Compared to natural pasture in both dry land farm and degraded dry land farm total N showed approximately 43% decrease and available P content decreased 50% in dry farm land. Also cation exchange capacity, microbial respiration, MWD and total porosity decreased and soil bulk density increased significantly in degraded dryland farm compared to natural pasture. Maximum runoff and sediment loss were measured in the abandoned dry land farm and currently being used dry land farm. Minimum runoff and sediment loss were produced in pasture with good vegetation cover. Percentage of organic matter, total N and available P in sediment was higher in the first hour experimental simulation compared to the second one. Total removal of these chemical components was evaluated in the dryland farming. Overall results indicated that cultivation and disturbance of the pasture in the given area caused a great decrease in soil quality and made the surface too sensitive for soil erosion.

2. Introduction

Understanding the effects of land use and land cover changes on soil properties have implications for devising land management strategies for sustainable use. This kind of information can be employed to forecast the likely effects of any potential changes in land use on soil properties. As it is well known, for instance, the destruction of vegetative cover can promote soil erosion that eventually increases the magnitude of soil-related constraints to crop production. Generally, a sound understanding of land use effects on soil properties provides an opportunity to evaluate sustainability of land use systems (Bewket and Stroosnijder, 2003).

Soil quality assessment emphasizes on both inherent and dynamic soil properties and processes. Dynamic soil quality focuses on the top 20 to 30 cm and describes the status or condition of a specific soil due to relatively recent land use or management decision (Karlen *et al*, 2003). Soil erosion is one the most significant forms of land degradation and is greatly influenced by land use and management (Erskin and Saynor, 1996). Soil erosion can lead to decreased rangeland productivity through the loss of organic matter and plant nutrients (Glordanego *et al*, 2003). Accelerated erosion and change in soil surface hydrology have been reported under conditions of reduced vegetation cover and altered soil structure (Linse *et al*, 2001). When a soil is plowed and exposed to the air, changes in organic matter quality are also accompanied with a decrease in soil moisture and an increase in the soils potential for erosion processes such as slaking and dispersion (Mc Dowell and Sharpley, 2002). The soil "A" horizon often contains significant amounts of organic matter which improves infiltration and increases soil water holding capacity. Therefore, removal of the "A" horizon can lead to increased erosion of underlying soil horizon (Pimental *et al*, 1995). The detachment and erosion of fine particles during overland flow can decrease the productive capacity of a soil (Sharpley and Smith, 1983). Quite often, these fine particles carry with them a much greater concentration of sorbed nutrients than the bulk soil they originated from (Sharpley and Smith, 1991).

The high risk of degradation in rangelands and forests in western Iran is considerable. Because of topography, soil weak structure and low organic matter, rangelands of Chaharmahal & Bakhtiary located in west of Iran are very much sensitive to soil degradation and erosion. The conversion of rangelands to dryland farming increases degradation in these soils. Improper management and land use change in highly undulating lands in Cheshmeh-Ali region of Chaharmahal & Bakhtiary province seemed to affect the soil quality. Therefore this study was conducted to (i) the impact of different land uses on soil quality indicators in the given study area, (ii) estimating run off and soil loss in different land uses, and (iii) calculating organic matter and nutrient elements in sediment in different land uses.

3. Materials and Methods

The study area is located in Cheshmeh Ali region (Solijan) in Chaharmahal & Bakhtiary province, western Iran (51º 15′ 57.6″ - 51º 16′ 18.7″ N, 31º 37′ 36″ - 31º 37′ 41.8″ E). Average of elevation in this region is 2266 m. the mean annual rainfall and temperature is about 410mm and 11^{oC}, respectively. Soils of the study site were classified as "Fine Clayey, Mixed, Active, Mesic, Calcic Haploxeralfs" according to soil taxonomy. Four different land uses were studied in this region including a pasture with good vegetation cover (>20%), a pasture with poor vegetation cover (<10%), a currently being used dryland farm and a degraded dryland farm which has not been used for 8 years. Soil samples were taken from the depth of 0-10 cm in a randomized design with four replications. Soil quality attributes including organic matter content, total N, available P, cation exchange capacity, microbial respiration, mean weight diameter, bulk density, soil porosity and infiltration rate were determined according to page (1992). A rainfall simulator was run for 2 hours with intensity of 60 mm/h to estimate the potential of sediment, runoff and nutrient loss in the selected land uses.

4. Results and discussion

The conversion of rangeland with good vegetation cover to another land use has caused a decrease in organic matter, total N and available P content (Table 1). Change of the pasture with good vegetation cover to a pasture with poor vegetation cover, an abandoned degraded dryland farm and dryland farm results a decrease in soil organic matter (SOM) 26.8%, 60.9% and 68.8%, respectively. Land use practices that have detrimental effects on SOM content have far-reaching implications because of the multiple roles SOM plays in soil quality (Wild, 1996). Cultivation is the most important factor responsible for organic matter decline, particularly in 0-15 cm of topsoil. Many studies show that SOM content in grasslands decreases after tillage (Gilley *et al*., 1997) which is mostly due to an increase in soil organic matter decomposition rate. The removal of topsoil through erosion and the mixing of subsoil with much lower OM with topsoil can also result in SOM reduction in the topsoil. The total N content in both dryland farm and degraded dryland farm decreased about 43% in compared to pasture with good vegetation cover. Available P content in pasture with good vegetation cover, pasture with poor vegetation cover, degraded dryland farm and dryland farm were 47.9, 43.3, 28.1 and 23.5 mg/kg, respectively. The highest decrease in available P (50.9% as compared to pasture with good vegetation cover) occurred in dryland farm. The reduction in total N and available P content is mostly due to the removal of organic matter enriched topsoil in erosion processes. The CEC in pasture with good vegetation cover, pasture with poor vegetation cover, dryland farm and degraded dryland farm were 31.7, 29.5, 26.9 and 19.9 Cmol (+)/kg soil. The highest decrease, 37.2% as compared to pasture with good vegetation cover, was observed in degraded dryland farm (Table 1).

Soil respiration is the production of CO_2 or the consumption of O_2 as a result of microbial or plant roots metabolism. Reduced levels of root and microbial respiration due to poor aeration have been found in compacted and non-tilled soils (Linn and Doran, 1984). The maximum soil respiration was 184 mg C (CO_2)/day/kg soil at 25˚C in pasture with good vegetation cover and the lowest was 79 mgC (CO_2)/day/kg soil in degraded dryland farm (Table 1). The highest values of MWD were reported in pasture with good vegetation cover, whears a considerable decrease (72.9%) was shown in degraded dryland farm. Total porosity decreased with Pasture land use change. Soil bulk density was increased significantly compared to natural pasture in degraded soils (Table 2).

Surface run off increased in the following order: Pasture with good vegetation cover, pasture with poor vegetation cover, dryland farm and degraded dryland farm. Total surface run off was respectively 22.6, 18.8, 11.7 and 3.9 lit/m^2 (Table 3). Run off was less in dryland farm compared to degraded dryland farm because of plowing and higher roughness in dryland farm. In addition to physical crust in degraded dryland farm prevent of infiltration and increase run off in this land use. Maximum sediment yield in the four times was observed in dryland farm. Total sediment in 2 hours increased in the following order: pasture with good vegetation cover, pasture with poor vegetation cover, degraded dryland farm and dryland farm (Table 4). Soil loss in dryland farm increased because of tillage operations break up the soil aggregate and exposing soil particles to splashing and transport. In addition to the soil of agriculture land is tilled, which results in the compaction of lower soil horizons (Allegre *et al*, 1986). Hence compaction increases water retention by the capillary effects. Therefore rainfall produced larger soil erosion. Soil surface horizon includes more organic matter, which this component accompanies with fine particles such as clay, are removed throughout the soil erosion processes. Maximum organic matter loss was in dryland farm with 43.59kg/ha after 2 hours rainfall simulation and minimum of it was shown in pasture with good vegetation cover. Total N loss in pasture with good vegetation cover, pasture with poor vegetation cover, degraded dryland farm and dryland farm were 0.23, 1.85, 2.13 and 4.83 kg/ha after 2 hours. Maximum available P loss was in dryland farm with 9.35 kg/ha and minimum it was 0.43 kg/ha after 2 hours in pasture with good vegetation cover (Table 5). Percentage of organic matter, total N and available P in sediment was higher in the first hour in compared to the second one. This is mainly due to the fact that fine particles are removed at the beginnings of the rainfall event.

Table 1 Some of soil chemical and biological characteristics in different land uses

Land use	**Soil respiration (Mg C (CO_2)/Kg soil/day)**	**OM (%)**	**TN (%)**	**available P (mg/kg)**	**CEC ($Cmol^+$/kg)**
Pasture with good vegetation cover	184^{a}	3.17^{a}	0.21^{a}	47.9^{a}	31.7^{a}
Pasture with poor vegetation cover	160^{b}	2.32^{b}	0.2^{a}	43.3^{b}	29.5^{b}
Dryland	102^{c}	0.99^{d}	0.12^{b}	23.5^{d}	25.9^{c}
Degraded dryland	79^{d}	1.24^{c}	0.12^{b}	28.1^{c}	19.9^{d}

Means followed by the same letters are not significant different at 95% probability level

Table 2 Some of soil physical characteristics in different land uses

Land use	**MWD (mm)**	**Bulk density(g/cm^3)**	**Porosity (%)**
Pasture with good vegetation cover	1.18^{a}	1.11^{d}	41^{a}
Pasture with poor vegetation cover	1.08^{b}	1.18^{c}	37.5^{b}
Dryland	0.41^{c}	1.26^{b}	32.3^{c}
Degraded dryland	0.32^{d}	1.34^{a}	27.8^{d}

Means followed by the same letters are not significant different at 95% probability level

Table 3 Total runoff in four running times of experiment during 2 hours rainfall simulation

Land use	**Run off (lit/m^2)**				
	0-30 min	30-60 min	60-90min	90-120 min	0-120min
Pasture with good vegetation cover	-	-	0.4^{d}	3.5^{d}	3.9^{d}
Pasture with poor vegetation cover	0.1^{b}	1.5^{c}	3.1^{c}	7.0^{c}	11.7^{c}
Dryland	0.1^{b}	3.3^{b}	5.1^{b}	10.3^{b}	18.8^{b}
Degraded dryland farm	0.3^{a}	4.1^{a}	7.5^{a}	10.7^{a}	22.6^{a}

Means followed by the same letters are not significant different at 95% probability level

Table 4 Total Soil loss in four running times of experiment during 2 hours rainfall simulation

Land use	**Soil loss (g/m^2)**				
	0-30 min	30-60 min	60-90min	90-120 min	0-120min
Pasture with good vegetation cover	-	-	2.0^{d}	4.6^{d}	6.6^{d}
Pasture with poor vegetation cover	1.4^{b}	11.3^{b}	25.0^{c}	31.2^{c}	68.9^{c}
Dryland	2.0^{a}	28.0^{a}	121.0^{a}	210.0^{a}	361.0^{a}
Degraded dryland farm	1.5^{b}	24.8^{a}	34.9^{b}	77.6^{b}	138.8^{b}

Means followed by the same letters are not significant different at 95% probability level

Table 5 Percentage of OM, TN and Available P in first and Second rainfall simulating in different Land Uses

Land use	OM(%)		Total N(%)		P (mg/kg)	
	1 hour	2 hour	1 hour	2 hour	1 hour	2 hour
Pasture with good vegetation cover	-	3.64[a]	-	0.35[a]	-	65.02[a]
Pasture with poor vegetation cover	3.19[Aa]	2.53[Bb]	0.27 [Aa]	0.25[Bb]	66.69[Aa]	61.83[Ba]
Dryland	1.36[Ac]	1.19[Bd]	0.15[Ac]	0.15[Bc]	30.10[Ac]	31.27[Bb]
Degraded dryland farm	1.57[Ab]	1.39[Bc]	0.17[Ab]	0.13[Bd]	35.12[Ab]	26.08[Bc]

Means followed by the same letters are not significant different at 95% probability level

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